THE GORGONACEÆ AS A FACTOR IN THE FORMATION OF CORAL REEFS

By L. R. Cary
Department of Biology, Princeton University

Six plates

THE GORGONACEÆ AS A FACTOR IN THE FORMATION OF CORAL REEFS.

By L. R. Cary.

INTRODUCTION.

An important constituent of the limestone of coral reefs is the calcium carbonate secreted in the skeletal structures of Anthozoa and marine calcareous algæ. Representatives of the Hydrozoa were important reef-formers in past geological epochs, but in the formation of modern reefs they constitute a minor factor. Representatives of the Anthozoa—the stony and flexible corals—are among animals the only important contributing agents in the formation of the modern reefs.

The formerly prevailing idea as to the relative importance of animal and vegetable organisms in reef formation underwent extensive change as a result of the borings at the island of Funafuti, in the Ellice Islands, made under the direction of a committee of the Royal Society of London. The examination of the cores from these borings showed that in this particular region calcareous algæ of the genus *Halimeda* had been a very active agent in the accumulation of limestone. At the bottom of the lagoon there was a depth of somewhat more than 100 feet where the deposit was made up almost entirely of the remains of this form and the skeletons of Foraminifera. In the body of the reef, and at a greater depth at the bottom of the lagoon, the abundance of material formed by the activity of these algæ was very much less than in the former boring, so that, when the entire deposit of limestone is considered, the algæ are a much less important factor than is indicated by the character of the surface deposits within the lagoon. Foraminifera and "other organisms" were found to make up a considerable portion of the limestone brought up in the course of both borings.

Of the animals which (by their power of secreting calcium carbonate from sea-water) have been designated as reef-builders the Madreporaria, among modern forms, have attracted the most attention on account of the character of their skeleton. In all these animals the skeletal growth is apparent from the early development of the colony, and after the death of the polyps the skeleton retains for a long time those structural characteristics which distinguish the different species. Of the Alcyonaria, those types alone which secrete a massive skeleton, *i. e.*, one in which the spicules are fused to a solid mass, have received adequate consideration as contributing to reef formation. Many of the other Alcyonaceæ, which when alive form much larger colonies than those last-mentioned, leave no conspicuous remains, as the skeletal spicules are scattered soon after the death of that portion of the colony by which they were secreted.

On many reefs, *e. g.*, on portions of the Great Barrier Reef of Australia (Saville-Kent) and those of the Philippine Islands,[1] the Alcyonaceæ, whose skeletons consist of loose spicules, constitute a large part of the lime-secreting fauna. Their spicules are, however, so small and so easily broken apart that they have not been recognized in samples of the coral rock from these reefs. Saville-Kent, in writing of the "Alcyonarian reefs" of Australia, states that the amount of lime secreted as spicules by these forms must be large, but is not available for addition to the reef until the death of the colony and the disintegration of the cœnenchyma have set free the spicules. Although a considerable portion of his work is devoted to a consideration of the rate at which reef-formation takes place, he dismisses the matter of the contribution of lime by the Alcyonaria with the above statement.

In the Florida-Antillean region the most abundant representatives of the Alcyonaria are the plume-like Gorgonaceæ; but in this region the only forms which have a dense lime-bearing axial skeleton belong to the family Isidæ. All other forms have free spicules which are scattered on the disintegration of the living tissues.

On all the coral reefs of the Florida-Antillean region which the writer has visited, the area occupied by living coral is so small, in proportion to the entire reef area, that it has seemed to him beyond question that some other organisms must be more actively participating in the laying down of lime on the reef. In many localities the Gorgonians growing on the shallow portions of the reef—down to 6 fathoms—constitute by far the largest part, either numerically or in bulk, of the organisms permanently attached to a given reef area. Besides, the presence of Gorgonian spicules in nearly all bottom samples from the reef, and even in the soft mud from the channels between the reefs, indicates that they remain in a recognizable condition for a considerable time after the disintegration of the colony and might be incorporated in the reef limestones before they had undergone marked erosion. On the basis of the two last-mentioned facts it seemed to me evident that the Gorgonians must be an important contributing factor in reef limestone formation. The greater part of the time during a stay of six weeks at the Marine Laboratory of the Carnegie Institution of Washington at Dry Tortugas, Florida, during the summer of 1914, was therefore devoted to a study of this problem.

Three factors must be taken into consideration in order to determine the amount of material contributed to reef-formation by the Gorgonians during any given time: First, the amount of lime held as spicules in the tissues of these colonies; second, the number of Gorgonians present on any reef area; and third, the number of colonies which will set free their spicules on account of the death and subsequent disintegration of their cœnenchyma.

[1]Based upon a private communication from Mr. S. F. Light, instructor in biology at the University of the Philippines, Manila.

SPICULE CONTENT.

In the determination of the amount of spicules in any colony, the following procedure was carried out. The colony was removed from the reef without injury to any portion except the expanded base. As in most instances the expanded basal portion of the colony inclosed a mass of calcareous material which could not be easily separated without the loss of some of the Gorgonian tissues, each colony was cut off close to the base and the base was discarded. The colony was weighed while still wet, cut into small pieces, and the living tissues destroyed by treatment with caustic soda. As a practical working method, it was found most satisfactory to treat the fragments of a colony with a cold 25 per cent solution of the caustic and to remove the pieces of the chitinous axial skeleton rather than to take the time to destroy the latter by prolonged boiling. When the organic material of the cœnenchyma had been destroyed by the caustic solution and sufficient time had been allowed for all of the spicules to settle to the bottom of the jar, the liquid was decanted off and the spicules washed repeatedly in rain-water until no trace of organic debris could be detected in the wash-water. After the last washing, the spicules were collected on a weighed filter, the filter and spicules were dried for 12 hours in a water bath kept at 100° C. and carefully weighed after cooling in a desiccator to room temperature.

The reason for making these determinations upon material weighed in a moist condition rather than after drying, which would frequently have been more convenient, was that by the use of the first-mentioned method, the results showed the proportion of spicules to the fresh weight of any colony immediately after it had been collected. This basis of computation made it possible to secure a tolerably accurate estimate of the spicule content of any mass of Gorgonians by simply separating the several species represented and determining the weight of each one.

In practice, the method worked out satisfactorily except for *Gorgonia acerosa*. Out of 14 analyses attempted on this form, only 3 could be completed. In all of the other attempts, as soon as the material was subjected to the action of the caustic solution, a thick sirupy mass was formed, in which spicules remained suspended for an indefinite time. Even after the dilution of such a mass with ten times the original volume of water, the spicules were held in suspension, nor could the liquid be forced through a suction filter to separate the spicules. After a few analyses of this form had been attempted, and the results compared, it was found possible to recognize on the reef those individuals which could be successfully disintegrated by the caustic. Presumably this difference in reaction is dependent upon a physiological (metabolic) condition of the Gorgonian colony, but of all those studied it was observed in this species alone.

Previous studies on the ecology of the Gorgonians on the reefs about the Tortugas islands had shown that at least nine-tenths of the bulk of these animals on any reef area are made up of individuals of not more than 12

TABLE 1.- *Percentage by weight of spicules in Gorgonian colonies.*

Species.	No. of specimen.	Fresh weight of colony.	Weight of spicules.	Spicules.	Average spicules.
		grams.	*grams.*	*p. ct.*	*p. ct.*
Briareum asbestum	1	51.00	14.084	27.54	26.66
	2	79.00	19.184	24.28	
	3	246.00	84.198	31.98	
	4	46.00	11.952	25.98	
	5	48.00	11.382	23.59	
Eunecia rousseaui	1	3.25	0.866	26.64	35.60
	2	46.00	16.335	35.51	
	3	78.50	27.370	34.86	
	4	196.00	87.400	44.08	
	5	338.00	121.588	38.93	
Eunecia crassa	1	33.50	7.706	23.00	22.36
	2	114.00	23.487	20.93	
	3	121.00	29.487	24.36	
	4	56.00	10.371	18.51	
	5	48.50	12.128	25.00	
Plexaura flexuosa	1	13.00	5.057	38.90	30.66
	2	23.00	5.486	23.85	
	3	191.00	63.465	33.22	
	4	145.00	40.164	27.67	
	5	45.00	13.300	29.77	
Plexaura homomalla	1	84.00	20.298	24.57	27.41
	2	33.00	9.820	29.76	
	3	320.00	85.696	26.78	
	4	113.00	28.916	25.59	
	5	186.00	56.358	30.35	
Pseudoplexaura crassa	1	91.00	22.349	24.56	21.48
	2	291.00	58.200	20.00	
	3	233.00	45.829	19.66	
	4	569.00	105.000	18.49	
	5	1944.00	539.000	27.72	
Plexaurella dichotoma	1	49.75	17.309	34.79	35.86
	2	83.00	30.538	36.79	
	3	201.00	67.707	33.68	
	4	39.00	13.993	35.72	
	5	15.50	5.940	38.32	
Plexaurella sp.	1	250.50	61.998	24.75	24.92
	2	31.00	7.699	24.83	
	3	28.00	7.264	25.87	
	4	129.00	31.367	24.31	
	5	14.00	3.498	24.82	
Gorgonia flabellum	1	29.00	6.186	21.27	22.33
	2	50.00	10.947	21.89	
	3	117.50	27.273	23.21	
	4	67.00	12.491	18.63	
	5	2.70	0.855	31.66	
Gorgonia acerosa	1	12.50	2.219	17.75	19.75
	2	50.50	13.513	26.76	
	3	68.00	10.719	15.75	
Gorgonia citrina	1	10.00	3.359	33.59	35.05
	2	16.00	4.967	31.04	
	3	23.00	9.252	39.24	
	4	22.00	8.104	36.26	
	5	25.00	8.785	35.14	
Xiphigorgia anceps	1	78.00	17.942	22.97	25.83
	2	18.00	4.926	26.25	
	3	178.00	45.050	25.23	
	4	11.00	3.258	29.61	
	5	14.50	3.642	25.11	
Average percentage of spicule content for the 12 species					27.40

species. The spicule determinations were consequently restricted to these more abundant forms. In selecting material for the determination, colonies of various sizes were taken, in order to have the final averages cover as wide a series of the different ages of the colonies as was possible without using the larger specimens of any species. The results of the determination on five[1] specimens of the several species are shown in table 1.

As would be expected, those forms having the thickest layer of cœnenchyma about the horny axis showed the highest percentage of spicules. Those also in which the cœnenchyma is most dense, *e. g.*, *Eunecia rousseaui*, have a much higher spicule content than others in which the cœnenchyma is soft—for example, *Pseudoplexaura crassa*, in which the entodermal canals and the polyps are relatively very large. This last-mentioned difference becomes much more evident when the dry weight of the colonies is taken as the basis for computing the percentage of spicules. In *Eunecia rousseaui* the proportion between the fresh weight and the dry weight was as 100 to 85, while in *Pseudoplexaura crassa* it was as 100 to 55. The same characteristic was especially noticeable in *Briareum*, in which (although the central axis consists entirely of interlaced spicules) the spicule content was smaller than in several other forms and, indeed, less than the average for the entire 12 species on which determinations were made. That the size of the spicules is also an important factor is shown by the fact that while all members of the genus *Gorgonia* have a relatively thin cœnenchyma, the presence of very small, densely packed spicules brings the spicule content well up to that shown by other forms.

The data contained in table 1 were obtained primarily to give a basis from which the amount of spicules in any mass of Gorgonians could be computed without the necessity of making separate determinations on such large amounts of material as would necessarily be handled in an extended survey of the reefs. In order, however, to have a more reliable check for these computations, a series of determinations of the spicule content of the Gorgonians were made from a number of squares, each with sides a yard in length. The results of these determinations are shown in table 2.

In securing the material for these determinations, a square frame made from iron pipe, with an area of one square yard, was thrown to the bottom without any previous observation of the number of Gorgonians there present. After their removal, the colonies were sorted, those of any one species being kept together, and determination was made of the total amount of spicules for each kind. For these observations the only selection made was that in practically all instances the specimen was gathered on portions of the reefs where the water was sufficiently shallow to permit one to wade.

Squares 1 to 6 were on the shallow reef west of Loggerhead Key and were scattered along a line some 2 miles in length. Squares 7 to 14 were taken along a line about 0.5 mile in length on the east side of Loggerhead Key. Square 15 was on a reef about 3.5 miles east of Loggerhead Key, where the Gorgonian fauna was very sparse, but was included to make the

[1]Only three determinations were carried out on *Gorgonia acerosa*, for the reasons previously mentioned.

average truly representative of the condition throughout the reefs within this group of islands. Squares 16 to 18 were on the outer, exposed side of a long reef which slopes rapidly into the deep water of the Rebecca Shoal channel, and is the most exposed location where collections were made in shallow water. Squares 19 and 20 were on a very shallow protected reef where wave action and currents are at their minimum for this region. Altogether, the conditions represented by the areas chosen for these collections fairly represent those under which the Gorgonians are growing on all the reefs about the Tortugas groups. Since all of the species included in these determinations occur on the reefs in depths from just below low-tide mark to 6 fathoms, the fact that the collections were made in shallow water does not introduce any unusual condition which could invalidate the results secured.

TABLE 2.—*Weight of Gorgonians taken from a square yard on the crests of shallow reefs about Dry Tortugas, and the amount of spicules for each square.*

Square.	Location of square.	Weight of Gorgonian colonies.	Weight of spicules.
		lbs.	*lbs.*
No. 1	Shallow reef west of light-house on Loggerhead Key	9.25	2.514
2	Outer shallow reef northwest from light-house	16.75	4.92
3	West Reef opposite light-house wharf	7.50	1.875
4	West Reef opposite north end of Loggerhead Key	4.25	1.19
5	West Reef north from laboratory wharf	11.75	2.89
6	West Reef north by east from Loggerhead Key	8.50	2.45
7	East Reef southeast from light-house, sandy bottom with scattered coral heads	25.00	6.94
8	East Reef south from light-house, rough bottom	3.25	0.84
9	East Reef south by west from light-house, near shore	5.00	1.50
10	East Reef, very shallow portion southeast from light-house, on north side of reef	3.00	0.91
11	East Reef, central part of shallow area	4.75	1.43
12	East Reef, south side of shallow area	7.50	2.25
13	East Reef northeast from light-house; in 1 fathom	20.50	[1]4.10
14	East Reef, east from laboratory	2.00	0.56
15	Reef southwest of Bird Key	1.50	0.45
16	Outer edge of Bush Key reef, at north end	5.00	1.22
17	Outer edge of Bush Key reef, near entrance to 3-foot channel	7.50	1.875
18	Outer edge Bush Key reef, southeast from Fort Jefferson	3.75	1.125
19	On shallow reef northwest from Fort Jefferson	4.25	1.180
20	On same reef, west from Fort Jefferson	6.25	1.650
Average weight of spicules from the 20 square yards			2.1225

[1]The Gorgonian fauna of this square was made up entirely of the two species *Gorgonia flabellum* and *G. acerosa*, so that the weight of spicules in proportion to the weight of the mass of colonies is decidedly lower than the average for other squares.

The very marked differences in abundance of the Gorgonian fauna seen when square 7 is compared with square 15 may be found over any large reef area. In some particular locations, comparatively large areas, several hundred yards in extent, are found where the Gorgonians are more abundant than on square 7, although every reef has areas where nothing but bare limestone or coral sand occurs. As a general feature of most of the shallow reefs within the Tortugas group, the Gorgonians are, however, the most prominent feature of the topography, usually outnumbering all other organisms of any noticeable size. The locations of the squares mentioned above are shown on the map (plate 100).

DISTRIBUTION OF GORGONIAN COLONIES ON THE REEFS ABOUT TORTUGAS.

In order to obtain a reliable estimate of the number of Gorgonian colonies occurring on a considerable area of one of the typical reefs, a series of counts (made by the use of the square-yard frame of iron pipe) were made along a line running north-northwest from the laboratory wharf on Loggerhead Key, extending across the west reef from its inner edge, over the shallow crest and down its outer slope to a depth of about 6 fathoms. On the shallower portion of the reef the counts were made about 40 feet apart. Farther out, where the increasing depth of water made it impossible to identify with certainty any of the species except *Gorgonia flabellum* and *Gorgonia acerosa*, the counts were made about 60 feet apart until the 6-fathom line was reached. Here the counts were discontinued, as dredgings had shown that beyond this point the Gorgonian fauna is comparatively scanty and for the most part made up of different forms from those occurring on the reefs in shallow water. The results of this series of counts is shown in table 3.

TABLE 3.—*Gorgonians counted on line across outer reef west of Loggerhead Key.*

1.	Gorgonia acerosa	1
	Plexaura flexuosa	2
	Eunecia crassa	2
2.	No Gorgonians.	
3.	Plexaurella dichotoma	1
	Gorgonia flabellum	1
4.	No Gorgonians.	
5.	Do.	
6.	Gorgonia flabellum	1
	acerosa	1
	Plexaura flexuosa	1
	Eunecia crassa	2
7.	Gorgonia acerosa	1
	Plexaura flexuosa	1
8.	Gorgonia flabellum	2
	Plexaura flexuosa	4
	Eunecia crassa	4
	rousseaui	2
	sp	1
	Briareum sp	2
9.	Gorgonia flabellum	2
	Plexaura flexuosa	2
	Eunecia crassa	1
10.	Gorgonia flabellum	2
	acerosa	2
	Plexaura flexuosa	2
	Briareum asbestum	1
	Pseudoplexaura crassa	1
	Eunecia rousseaui	1
	crassa	1
11.	Plexaura flexuosa	1
	Eunecia crassa	5
	rousseaui	1
12.	Plexaura flexuosa	4
	Gorgonia flabellum	1
	Plexaurella dichotoma	2
	sp	1
12.	Eunecia rousseaui	1
	crassa	2
13.	Gorgonia flabellum	1
	Plexaura flexuosa	3
	Eunecia crassa	4
	rousseaui	2
14.	Gorgonia acerosa	1
	flabellum	1
	Eunecia rousseaui	2
15.	Plexaura flexuosa	1
	Eunecia rousseaui	2
16.	Plexaura flexuosa	2
	Pseudoplexaura crassa	2
17.	Gorgonia flabellum	1
	Plexaurella dichotoma	1
	Eunecia crassa	2
18.	No Gorgonians.	
19.	Plexaura flexuosa	1
	Gorgonia acerosa	1
20.	Gorgonia acerosa	1
21.	No Gorgonians.	
22.	Gorgonia flabellum	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	5
	Eunecia crassa	7
23.	Gorgonia acerosa	6
	flabellum	2
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	2
24.	No Gorgonians.	
25.	Gorgonia flabellum	4
	acerosa	2
	Plexaura flexuosa	2
	Eunecia rousseaui	1
	crassa	4
26.	Gorgonia flabellum	3
	acerosa	2
27.	Gorgonia flabellum	2
28.	Gorgonia flabellum	3
	acerosa	1
	Plexaura flexuosa	1
	Pseudoplexaura crassa	1
	Eunecia crassa	6
29.	Gorgonia flabellum	2
	acerosa	1
	Plexaurella dichotoma	2
	Eunecia rousseaui	1
[1]30.	Gorgonia flabellum	2
	acerosa	1
	Other forms	4
31.	Gorgonia flabellum	2
32.	Gorgonia acerosa	2
	Other forms	4
33.	Gorgonia flabellum	2
	acerosa	1
	Other forms	3
34.	Other forms	5
35.	Gorgonia acerosa	1
36.	Gorgonia acerosa	1
	Other forms	3
37.	Other forms	2
38.	Gorgonia acerosa	3
	Other forms	2
39.	Gorgonia flabellum	3
40.	Gorgonia flabellum	2
	Other forms	4
41.	No Gorgonians.	
42.	Gorgonia acerosa	1
	Other forms	3
43.	No Gorgonians.	
44.	Gorgonia flabellum	2
45.	Gorgonia flabellum	1
	acerosa	1

[1]Beyond this point the depth of the water was too great to allow of the certain identification of any of the gorgonians except *Gorgonia flabellum* and *G. acerosa*. The number of individuals of all other species is therefore given under the caption "other forms."

Along this line, which was approximately 0.35 of a mile in length, in only 8 of the 45 counts made did the frame fall upon an area of bottom upon which no Gorgonians were growing. The largest number counted on any square yard was 17. The average for the whole 45 counts was 5.72. Counts upon a number of other reefs in different parts of the group show that the proportion of squares on which no Gorgonians were found was considerably higher along this line than that obtained by averaging all of the counts. The average of one empty square to each 5.6 of those counted as found in the series recorded in table 3 is almost twice as great as the average for all the counts made on the reefs about Tortugas, which was one empty square in each 10.03. Besides the counts along this line, other series were made on nearly all of the shallow reefs in the Tortugas group. The most important were the following (Plate 100):

(1)[1] A line about 2.5 miles in length running nearly northeast along the crest of the West Reef from opposite Loggerhead Key to the northwest channel. The average number of Gorgonian colonies for the 150 counts along this line was 8.97. In only 14 casts did the frame fall upon an area of barren bottom.

(2) A series of counts on 4 small reefs east of the northwest channel where in each instance the line of countings was extended from deep water on one side of the reef over its crest and down to deep water on the other side. The average number of Gorgonian colonies for the 30 counts made on 3 of the reefs in this locality was 10.86. In 3 casts the frame fell upon barren bottom.

(3) Along a line running north-northwest from the Pulaski Shoal buoy, from the edge of the Rebecca Shoal channel over the reef and to deep water on its inner side, 25 counts were made. The average number of Gorgonian colonies for 20 counts along this line was 7.62, while in only one of the casts did the frame fall upon an area of barren bottom.

(4) In a series of counts along the outer side of Long and Bush Keys, starting from the northwestern end of the former, extending along the northeast channel, and then down the outer face of the long reef to the southward, the average number of Gorgonian colonies found in 40 counts was 13.27. The number of squares upon which no Gorgonians occurred was 7. This series of counts extended over an area upon which there was a very unusual destruction of Gorgonians during the severe hurricane that had its center in the Tortugas region on October 17, 1910. The unusually large number of colonies found is probably due to the fact that the normal conditions for the Gorgonian fauna have not as yet been re-established. Nearly all of the colonies occurring on this section of the reef were of small size, so that the spicule content of the Gorgonians upon any square yard would be below the average found for the determination based upon the counts from other reefs.

[1]Details of the counts along these lines are given in tables 10 to 14 in an appendix to this paper.

(5) In a series of counts on a line extending along the axis of White Shoal, the average number of colonies to the square yard was 5.86 for 35 counts. On 5 squares no Gorgonians were found. In this series the conditions on the southern end of the shoals were exceptional and were again due to the hurricane of October 1910. At that time the larger portion of this end of the shoal was covered by a mass of broken coral and shell to a depth of 4 feet on the highest part of the reef. In January 1911 an area, roughly 2 acres in extent, was laid bare at low tide. Across the entire crest of the reef the water was 2 to 4 feet shallower than before the hurricane. In the course of the next 18 months all of this loose material had been washed away, so that the shoal was again back to its former level, but absolutely bare of Gorgonians. Within the interval since July 1912 a "set" of Gorgonians, almost entirely of a single species, *Gorgonia acerosa*, has become established over this area, so that a determination of the colonies on 75 square yards (including 15 in the series along the axis of the reef) gave an average of 4 to the square yard. On the northern three-fifths of this shoal, the Gorgonian fauna had not suffered any extensive injury from the hurricane and was of the same character as that found generally on the other reefs.

TABLE 4.—*Average weight of a single Gorgonian colony.*

Species.	Average weight.	Species.	Average weight.
	lbs.		*lbs.*
Briareum asbestum	2.00	Plexaurella dichotoma	0.75
Eunecia rousseaui	1.00	sp	0.75
crassa	0.30	Gorgonia flabellum	1.00
Plexaura flexuosa	1.00	acerosa	3.00
Pseudoplexaura crassa	2.50	citrina	0.50
Plexaura homamalla	1.00	Xiphigorgia anceps	0.50

As a basis for the computation of the weight of Gorgonian colonies occurring on any square yard of reef area, the figures given in table 4 show the weight of a colony of the several species listed as determined by averaging the weight of 20 colonies of medium size.

Computed upon this basis, the average weight of the Gorgonian colonies collected on the squares along the reef west of Loggerhead Key is 7.32 pounds. Estimating by the average percentage of spicules (27.40 per cent) as determined for the 11 species as shown in table 1, the average spicule content for each square yard is 2 pounds. This result approaches very closely that found by actual determination of spicule content of the Gorgonian colonies on 20 square yards as given in table 2. Since the number of colonies per square yard was in this series the smallest found in the counts on any reef, the spicule content when estimated upon the same basis would be considerably greater for many of the other reefs than the amount determined by actual analysis as given in table 2.

Since the foregoing statement was written, additional data upon this question, secured during the summer of 1914, have shown that the above estimate is far below the average over the whole reef area.

The addition to the equipment of the laboratory of a "Dunn diving hood," by the use of which the study of any bottom in less than 30 feet of water is made practicable, has made it possible to secure extensive collections of the Alcyonarian fauna from the deeper reefs. In many instances the surface of the deeper reefs is covered with a dense shrub-like growth of Gorgonians of an average height of at least 3 feet. Since the surface of all of the reefs is very irregular and the Gorgonian colonies are usually attached to the higher points of the reef, many of them would reach above the level of one's shoulders as he was walking about over the reef. In general the bulk of the colonies of the most common species of Gorgonians was about twice as great as that determined for the same species from specimens collected on the shallow water reefs. The average weight of the colonies of a number of these forms taken from a reef in 18 feet of water is given in table 5.

TABLE 5.—*Weight of Gorgonian colonies from deep water.*

Species.	Weight.	Species.	Weight.
	lbs.		*lbs.*
Eunecia rousseaui	2.20	Pseudoplexaura crassa	4.25
crassa	0.75	Plexaurella dichotoma	2.00
Plexaura flexuosa	3.50	Gorgonia flabellum	3.00
homomalla	3.00	acerosa	5.00

The proportion of spicules in the tissues of those forms for which spicule determinations were made of specimens from the deeper reefs did not differ materially from that determined for specimens from the shallow reefs, so that the estimate of 5.38 tons to the acre as the amount of spicules held in the tissues of living Gorgonian colonies on the reefs about Tortugas would be, for those reefs in more than 15 feet of water, only about half the amount actually present.

DISINTEGRATION OF GORGONIAN COLONIES AND ADDITION OF THE SPICULES TO THE REEF-BUILDING MATERIALS.

The securing of accurate data bearing upon this phase of the problem has been the most difficult part of the investigation, since there is no readily available method by which the actual destruction of colonies over any reef area can be determined when the observations on the reef are limited to a comparatively short time each year; but observations bearing directly upon this point have been accumulated in the course of studies extending over a period of five years upon the growth-rate and ecology of the Gorgonians in this region, and some investigations on the time necessary for the disintegration of the cœnenchyma of Gorgonians were carried out in the summer of 1914.

Previous observations have shown that when a Gorgonian colony is removed from its attachment on the reef and allowed to lie on the bottom, where it will be moved about by the action of tidal currents or waves (or if it is suspended upside down), death follows within a comparatively short time. The time necessary for the complete disintegration of the cœnenchyma of a colony and the consequent liberation of its spicules after it had been removed from its attachment on the reef was determined for the 12 species which make up the most important element in the Gorgonian fauna of the region. The results of these experiments are shown in table 6.

TABLE 6.—*Time necessary for the complete disintegration of the cœnenchyma of Gorgonian colonies.*

Species.	Time of disintegration.	Species.	Time of disintegration.
	hrs.		*hrs.*
Briareum asbestum	48	Plexaurella dichotoma	60
Eunecia rousseaui	96	sp	48
crassa	68	Gorgonia flabellum	120
Plexaura flexuosa	32	acerosa	36
homomalla	24	citrina	30
Pseudoplexaura crassa	18	Xiphigorgia anceps	24

Under normal conditions on the reef, the greatest number of axial skeletons of dead colonies are found in positions which indicate that the tearing of the colony from its original attachment by wave-action is the cause of the greatest mortality. When destroyed in this manner, the spicules from any colony would be added to the limestone-forming materials on the reef within a few days, at most, from the time the colony was torn from the reef. Another active destructive agent, at least on the reefs about Tortugas, is the hydrocoralline *Millepora alcicornis*. On any reef numerous Gorgonian colonies are found, a part of the axial skeleton of which is incrusted with a growth of *Millipora*. The work of this destructive agent is particularly striking on colonies of *Gorgonia flabellum*. The axial skeleton of this species still retains its delicate lace-like pattern after it has been overgrown by the white *Millepora*. In many instances colonies are found in which the basal portion is entirely incrusted by this foreign growth, while the distal portion still bears the normal Gorgonian tissues, apparently as yet unaffected by the destruction of the cœnenchyma on the proximal portion. In all such colonies examined the disintegration of the cœnenchyma had taken place previous to the overgrowth of the axial skeleton by the *Millipora*, so that the Gorgonian spicules are set free little by little as the growth of the *Millipora* goes on. Very much the same effect is brought about by the upgrowth of incrusting Bryozoa about a colony. In this case, however, the incrusting organism grows over the surface of the cœnenchyma and the death of the latter is brought about on account of the cutting off of the supply of food and oxygen rather than by some toxic substance, as seems to be the cause of the death of the tissues in colonies overgrown by *Millepora*. The disintegration of the tissues of the cœnenchyma takes place slowly in colonies overgrown by the incrusting Bryozoa. Usually only the proximal portion of the colony is affected, while the tissues of the distal portion retain their normal activity.

So far as can be determined from observations extending over a period of five years on the reefs about Tortugas, there is no evidence of death from old age in any of the Gorgonians. Every colony lives until it meets a violent death through the agency of storms (wave action), by being overgrown by some other organism, or by its being set free on the reef through the disintegration of the material to which it was attached. Besides the tearing loose from their place of attachment of the Gorgonian colonies, another result of wave action is that frequently an amount of loose limestone debris sufficient to cover up the colonies is brought upon a reef, causing their death by excluding food and oxygen.

Table 7.—*Percentage of dead colonies on a reef.*

Date of examination.	No. of colonies.	No. of dead skeletons.	Percentage of dead skeletons.
June 1910........	548	64	11.67
January 1911....	No complete count.	136	[1]24.80?
July 1911........	456	92	20.17
July 1912........	456	97	21.27
September 1913..	608	82	13.26
July 1914........	642	78	12.14
			Aver. 17.22

[1]Computed upon the basis of the count of June 1910.

The facies of the Gorgonian fauna on any reef remains practically constant except for the introduction of the unusual factor of extensive destruction of colonies as an effect of severe storms. The determination of the number of axial skeletons of dead colonies on any reef is, therefore, the only practical method of determining the death-rate of these organisms on any reef area. This method, unfortunately, has one very important source of error, in that when a colony has been torn from its place of attachment it will most often be carried for a considerable distance from its previous position and will not be included in a count of dead skeletons on a restricted area of reef. A record of the entire number of certain species of Gorgonians found on a small protected reef east of Loggerhead Key has been kept continuously for five years, and affords the most comprehensive data available on this point. The record for this reef area from 1910 to 1914 inclusive is shown in the above table.

In this record the dead skeletons for the first and last two years alone represent a normal condition. The percentage for the other years is abnormally high on account of the fact that the unusual destruction on account of the hurricane of October 1910 fell within the period of the record. On other reefs within the group, the destruction of the Gorgonian fauna at that time was in some instances complete, *e. g.*, on the southern end of White Shoal. In another locality, on the northern end of Bush Key, the amount of spicules set free from disintegrated Gorgonian colonies was about 25 pounds to the square yard, over an area of nearly 100 square yards. On all of the reefs, except those in the most protected situations, the destruction at this time was very extensive, ranging from 15 to 100 per cent.

As heavy storms are of frequent occurrence throughout the Antillean region in late summer or early autumn, it is probable that a record extending over any considerable period of years would show that a fair estimate of the annual destruction of Gorgonians can be obtained by making an average over a period containing the date of a heavy storm. The percentage of 17.22 as the average for five years on the reef last mentioned will, therefore, represent the conditions on an unusually well-protected reef through such a period. On most of the reefs about the Tortugas group, the average destruction over a considerable period of years would unquestionably be considerably higher.

Table 8.—*Rate and character of the growth of certain Gorgonian colonies.*

Species of Gorgonian.	Years necessary to reach medium size.	Character of growth.
Briareum asbestum	...	Grows indefinitely from creeping stolon.
Eunecia crassa	2.5	Grows very slowly after reaching medium size.
rousseaui	3.0	Do.
Plexaura flexuosa	3.0	Do.
Pseudoplexaura crassa	2.5	Do.
Plexaura homomalla	4.0	Do.
Plexaurella dichotoma	3.0	Do.
sp	3.0	Do.
Gorgonia flabellum	4.0	Do.
acerosa	5.0	Keeps growing indefinitely, but very slowly, after 5 years.
citrina	2.0	Grows very slowly after this time.
Xiphigorgia anceps	3.0	Do.

Since the facies of the Gorgonian fauna on these reefs is practically unchanged from year to year under average conditions, a knowledge of the growth-rate of these forms affords a basis for determining the rate at which the lime is built up as spicules in the tissues of Gorgonian colonies. Records of the growth-rate of a considerable number of specimens of several species of Gorgonians have shown that the time necessary for such colonies to reach "medium" size, such as was used in making the determinations recorded in table 4, is comparatively short for all of the different species. The results of these records are shown in table 8.

In almost all of the species studied the growth is most rapid during the second year and becomes progressively slower from that time on. In a few species, particularly in *Gorgonia acerosa*, growth takes place for an indefinite period and there seems to be no definite size for the colony as there is for most other forms.

In relation to the stability of the facies of the Gorgonian fauna on any area, it has been observed that after a period of severe destruction by storm there is always an unusually large number of young colonies present on the reefs after the first breeding season following the cataclysm. At the end of the second year most of these colonies would have attained nearly the normal size and would have brought the amount of lime held as spicules up to the average amount.

ILLUSTRATIONS.

Plates 101 to 105 are from photographs of dried specimens of the twelve species of Gorgonians which were found to constitute the major part of the alcyonarian fauna on the reefs about Tortugas. All the figures, except Nos. 9 and 10, are of specimens rather smaller than the average size.

CONCLUSIONS NEW TO SCIENCE.

The results of this study show that over large reef areas, in the region about Tortugas at least, the Gorgonian fauna is by far the most important element contributing to the formation of reef limestones. On the basis of the data recorded in tables 2 and 3 the amount of spicules in the tissues of Gorgonian colonies would average at least 5.28 tons to the acre for all of the reefs in the Tortugas group.[1] In many restricted areas the amount is very much greater, as is shown by the bulk of the Gorgonian colonies growing in these localities, or in some instances by the amount of spicules actually set free on the reefs.

The figures given above represent only a potential contribution to reef formation but a study of the normal cycle of changes in the Gorgonian fauna of this region has shown that at least a fifth of this amount of calcium carbonate, as spicules, will be added to the reef limestones annually. There are wide fluctuations in the extent to which destruction of the Gorgonian colonies takes place in any single year, but the above estimate is well within the limits found by averaging the results obtained over a period of several years.

In many regions where representatives of the family Alcyonaceæ make up the greater portion of the Alcyonarian fauna the contribution to the reef limestone would be unquestionably greater than about the Tortugas where the family Gorgonidæ is alone represented by numerous specimens.

SUMMARY.

1. The Alcyonarian fauna of the Florida-Antillean region is composed almost entirely of representatives of the order Gorgonaceæ, in which the entire lime-bearing skeletal elements are spicules formed in the cœnenchyma. The Gorgonians are, however, very numerous on most of the shallow reefs, and the presence of their spicules in practically all bottom samples indicates that they are an important element in reef limestone formation.

2. When analyzed for percentage of spicule content of the 12 species occurring most abundantly about Tortugas, it is found that from 19.75 per

[1]See table 5.

cent (*Gorgonia acerosa*) to 35.86 per cent (*Plexaurella dichotoma*) of the fresh weight of the colonies is made up of spicules. The average spicule content for the 12 species was 27.4 per cent.

3. The fresh weight of the Gorgonian colonies growing upon a square yard from different reefs varied from 1.5 pounds to 25.0 pounds. The amount of spiculæ held in the tissues of these colonies varied from 0.45 pound to 6.94 pounds. The average weight of the spicules for the 20 determinations was 2.1225 pounds.

4. The number of colonies per square yard along a series of lines extending over a number of the reefs (see map) was as follows:

TABLE 9.

Line.	No. of squares.	Average No. of colonies.	No. of barren squares.	Line.	No. of squares.	Average No. of colonies.	No. of barren squares.
No. 1	45	5.72	8	No. 4	25	7.62	1
2	150	8.97	14	5	40	13.27	7
3	30	10.86	3	6	36	5.86	5

5. An estimate of the weight of the Gorgonian colonies from each square yard in the series of counts just mentioned, based upon the average weight of the colony for common forms (see table 4), gives an average of 2 pounds for line 1. The number of colonies to the square yard along this line was the least of any line on which counts were made. Even on the basis of this estimate, the weight of the spicules held in the tissues of living colonies would average 5.38 tons per acre.[1]

6. The cœnenchyma of all the species studied will be disintegrated, setting free the spicules, within 120 hours of the time they are broken from their attachment on the reefs (table 6).

7. There is no evidence of death from old age among Gorgonians. The most important destructive agent is wave-action, with its many effects. Incrusting organisms (*Millepora*, *Bryozoa*, etc.) are also a constant factor of considerable importance.

8. A series of records extending over 5 years for one reef shows that on an average about one-fifth of the total Gorgonian fauna is destroyed each year. (Table 7.) While the facies of the Gorgonian fauna remain practically constant approximately 1 ton of limestone, as spicules, is therefore added to the surface of each acre of reef area annually. Records of the rate of growth of the most common species of Gorgonians found in the Tortugas region have shown that nearly all of them reach medium size in from 2 to 5 years, and that growth takes place very slowly after that time. (Table 8.)

[1]See table 5.

TABLE 10.—*Details of counts along line No. 1* (*see page 350 and map*).

No.	Species	Count
1.	Gorgonia flabellum	1
	acerosa	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
	Eunecia crassa	5
2.	Gorgonia flabellum	2
	acerosa	1
	Briareum asbestum	2
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	2
	Eunecia crassa	5
3.	Gorgonia flabellum	3
	Plexaura flexuosa	4
	homomalla	2
	Eunecia rousseaui	2
	crassa	3
4.	Gorgonia acerosa	1
	citrina	6
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	1
5.	Plexaura flexuosa	3
	homomalla	1
	Eunecia crassa	5
6.	Gorgonia flabellum	2
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	2
	Eunecia rousseaui	4
7.	Barren.	
8.	Gorgonia acerosa	3
	citrina	4
	Xiphigorgia anceps	2
10.	Barren.	
11.	Gorgonia flabellum	2
	Xiphigorgia anceps	4
	Plexaura flexuosa	1
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	2
12.	Briareum asbestum	2
	Plexaurella sp	1
	Eunecia rousseaui	2
	crassa	5
13.	Gorgonia flabellum	2
	acerosa	1
	Eunecia crassa	4
14.	Gorgonia citrina	5
	Plexaura flexuosa	1
	homomalla	1
	Pseudoplexaura crassa	1
15.	Eunecia crassa	2
16.	Gorgonia acerosa	2
	flabellum	1
	Plexaurella dichotoma	2
	Xiphigorgia anceps	2
17.	Gorgonia acerosa	2
	flabellum	4
	Plexaura flexuosa	2
18.	Gorgonia flabellum	3
	Plexaurella sp	2
	dichotoma	2
	Eunecia rousseaui	2
	crassa	4
19.	Pseudoplexaura crassa	2
	Eunecia crassa	4
20.	Plexaura flexuosa	2
	homomalla	1
	Pseudoplexaura crassa	2
	Eunecia crassa	4
21.	Gorgonia acerosa	2
	flabellum	1
	Plexaura flexuosa	4
	Pseudoplexaura crassa	2
	Xiphigorgia anceps	3
22.	Gorgonia flabellum	3
	acerosa	4
	Xiphigorgia anceps	1
	Plexaurella sp	1
	dichotoma	2
	Eunecia crassa	6
23.	Barren.	
24.	Eunecia rousseaui	2
	crassa	10
25.	Pseudoplexaura crassa	3
	Plexaura flexuosa	7
	homomalla	1
	Plexaurella dichotoma	2
	Eunecia crassa	9
26.	Gorgonia flabellum	4
	acerosa	2
	Xiphigorgia anceps	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
27.	Plexaura flexuosa	4
	Pseudoplexaura crassa	1
	Eunecia rousseaui	2
	crassa	11
28.	Gorgonia flabellum	4
	acerosa	1
	Plexaurella dichotoma	3
	Briareum asbestum	2
	Eunecia crassa	7
29.	Gorgonia flabellum	1
	acerosa	3
	Xiphigorgia anceps	1
	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Eunecia rousseaui	4
30.	Pseudoplexaura crassa	3
	Plexaurella dichotoma	4
	Eunecia rousseaui	2
	crassa	6
31.	Gorgonia acerosa	1
	flabellum	3
	Plexaura flexuosa	3
	Plexaurella sp	1
	Pseudoplexaura crassa	2
	Eunecia crassa	5
32.	Plexaurella dichotoma	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
	Eunecia rousseaui	3
	crassa	4
33.	Gorgonia flabellum	2
	Plexaura flexuosa	3
	homomalla	1
	Plexaurella dichotoma	2
	Eunecia crassa	7
34.	Barren.	
35.	Barren.	
36.	Gorgonia flabellum	2
	acerosa	3
	Xiphigorgia anceps	1
	Gorgonia citrina	4
	Eunecia rousseaui	1
37.	Gorgonia acerosa	2
	Plexaurella sp	2
	Pseudoplexaura crassa	1
	Eunecia crassa	7
38.	Plexaurella dichotoma	2
	Plexaura flexuosa	4
	Eunecia rousseaui	2
	crassa	8
39.	Gorgonia flabellum	1
	Plexaura flexuosa	3
	homomalla	1
	Pseudoplexaura crassa	2
	Eunecia crassa	5
40.	Gorgonia flabellum	1
	acerosa	1
	Plexaura flexuosa	2
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	3
41.	Plexaura flexuosa	4
	homomalla	1
	Pseudoplexaura crassa	2
42.	Gorgonia acerosa	4
	Eunecia crassa	7
43.	Gorgonia flabellum	3
	acerosa	1
	Plexaurella dichotoma	2
	Eunecia crassa	4
44.	Eunecia crassa	6
45.	Pseudoplexaura crassa	1
	Plexaurella dichotoma	2
	Eunecia rousseaui	2
	crassa	5
46.	Gorgonia acerosa	2
	flabellum	3
	Plexaura flexuosa	2
	Pseudoplexaura crassa	1
47.	Plexaura flexuosa	2
	Plexaurella sp	1
	Eunecia rousseaui	2
48.	Plexaura flexuosa	2
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	3
	Eunecia crassa	4
49.	Gorgonia acerosa	3
	Xiphigorgia anceps	1
	Eunecia rousseaui	2
50.	Gorgonia acerosa	2
	flabellum	5
	Plexaura flexuosa	7
	Plexaurella dichotoma	3
	Eunecia crassa	8
51.	Eunecia crassa	4
52.	Gorgonia acerosa	1
	Plexaura flexuosa	2
	Eunecia crassa	3
53.	Gorgonia flabellum	2
	acerosa	1
	Plexaura flexuosa	2
54.	Gorgonia acerosa	1

TABLE 10.—*Details of counts along line No. 1*—continued.

55.	Plexaura flexuosa	3
	Plexaurella dichotoma	2
	Eunecia crassa	4
56.	Pseudoplexaura crassa	2
	Plexaurella dichotoma	1
	Eunecia rousseaui	2
	crassa	4
57.	Gorgonia flabellum	2
	Xiphigorgia anceps	1
	Gorgonia citrina	3
	Eunecia crassa	4
58.	Gorgonia acerosa	1
	Plexaurella dichotoma	3
59.	Barren.	
60.	Gorgonia acerosa	1
	Plexaura flexuosa	4
62.	Gorgonia flabellum	2
	Pseudoplexaura crassa	1
	Eunecia rousseaui	2
	crassa	6
63.	Gorgonia flabellum	2
	Plexaura flexuosa	4
	Plexaurella sp	2
	Eunecia crassa	3
64.	Gorgonia flabellum	3
	acerosa	1
	Eunecia rousseaui	2
65.	Gorgonia acerosa	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	4
	Eunecia crassa	5
66.	Plexaura homomalla	2
	Plexaurella dichotoma	3
	Eunecia rousseaui	2
	crassa	4
67.	Gorgonia flabellum	3
	acerosa	2
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	1
68.	Gorgonia acerosa	2
	citrina	4
	Plexaurella dichotoma	4
	Eunecia crassa	3
69.	Gorgonia flabellum	3
	Eunecia crassa	4
70.	Pseudoplexaura crassa	2
	Eunecia rousseaui	2
	crassa	4
71.	Gorgonia flabellum	1
	acerosa	1
	Xiphigorgia anceps	2
	Plexaurella dichotoma	3
72.	Plexaura flexuosa	3
	homomalla	1
	Briareum sp	2
73.	Barren.	
74.	Eunecia crassa	8
75.	Gorgonia flabellum	3
	acerosa	2
	citrina	3
	Plexaurella dichotoma	4
76.	Gorgonia acerosa	1
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	4
	Eunecia rousseaui	2
	crassa	5
77.	Gorgonia flabellum	2
	Plexaura flexuosa	2
	Plexaurella sp	1
	dichotoma	3
78.	Gorgonia flabellum	2
79.	Gorgonia flabellum	1
	acerosa	3
	citrina	2
	Plexaura flexuosa	2
	Eunecia rousseaui	4
80.	Gorgonia flabellum	2
	Plexaurella sp	2
	Pseudoplexaura crassa	2
	Eunecia crassa	4
81.	Plexaura flexuosa	4
	Plexaurella dichotoma	1
	Eunecia rousseaui	2
	crassa	4
82.	Gorgonia acerosa	2
	Pseudoplexaura crassa	2
83.	Plexaurella dichotoma	3
	Plexaura flexuosa	2
	homomalla	1
	Eunecia crassa	4
84.	Gorgonia flabellum	3
	acerosa	1
	Xiphigorgia anceps	4
	Plexaura flexuosa	2
85.	Gorgonia flabellum	3
	citrina	4
	Pseudoplexaura crassa	2
86.	Gorgonia flabellum	2
	acerosa	1
	Plexaura flexuosa	2
	Plexaurella dichotoma	8
	Eunecia crassa	5
87.	Eunecia rousseaui	3
	crassa	6
88.	Plexaura homomalla	2
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	6
89.	Gorgonia flabellum	3
	acerosa	2
	Xiphigorgia anceps	2
	Plexaura flexuosa	3
90.	Gorgonia acerosa	3
	Plexaurella dichotoma	7
91.	Barren.	
92.	Plexaura flexuosa	3
	homomalla	1
	Pseudoplexaura crassa	3
93.	Gorgonia flabellum	2
	citrina	5
	Plexaurella dichotoma	4
94.	Gorgonia acerosa	3
	flabellum	1
	Eunecia rousseaui	2
	crassa	5
95.	Xiphigorgia anceps	2
	Pseudoplexaura crassa	3
	Plexaurella dichotoma	7
96.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Eunecia crassa	4
97.	Eunecia crassa	2
98.	Gorgonia flabellum	2
	acerosa	3
	Plexaura flexuosa	5
	Eunecia crassa	7
99.	Gorgonia acerosa	1
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	5
	Eunecia rousseaui	7
100.	Gorgonia flabellum	2
	Xiphigorgia anceps	3
	Plexaura flexuosa	2
	Plexaurella sp	1
	Eunecia crassa	4
101.	Plexaurella dichotoma	7
	Pseudoplexaura crassa	2
102.	Plexaurella dichotoma	4
	Eunecia rousseaui	2
	crassa	4
103.	Gorgonia flabellum	2
	acerosa	3
	Plexaura flexuosa	3
	Plexaurella sp	2
	Eunecia crassa	4
104.	Gorgonia acerosa	2
	Plexaurella dichotoma	5
105.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	4
106.	Gorgonia flabellum	2
	Xiphigorgia anceps	2
	Eunecia rousseaui	1
	crassa	4
107.	Gorgonia flabellum	2
	acerosa	1
	citrina	4
	Plexaurella dichotoma	5
108.	Barren.	
109.	Barren.	
110.	Plexaura flexuosa	4
	homomalla	2
	Plexaurella dichotoma	5
	Eunecia crassa	5
111.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	4
	Eunecia rousseaui	1
	crassa	5
112.	Gorgonia flabellum	1
	Xiphigorgia anceps	2
	Plexaura flexuosa	2
	Plexaurella dichotoma	5
	Eunecia crassa	4
113.	Gorgonia flabellum	2
	citrina	5
	Pseudoplexaura crassa	3

Table 10.—*Details of counts along line No. 1*—continued.

114.	Gorgonia acerosa	3
	Xiphigorgia anceps	4
	Plexaura homomalla	2
	Briareum asbestum	2
115.	Xiphigorgia anceps	3
	Pseudoplexaura crassa	3
	Plexaurella dichotoma	5
	Briareum asbestum	2
116.	Gorgonia citrina	4
	Xiphigorgia anceps	3
	Plexaura homomalla	1
	Eunecia rousseaui	1
	crassa	3
117.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	5
	Briareum asbestum	2
118.	Gorgonia flabellum	3
	Plexaurella sp	1
119.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	3
	Plexaurella dichotoma	5
120.	Xiphigorgia anceps	2
	Plexaura flexuosa	2
	Pseudoplexaura crassa	3
	Eunecia rousseaui	2
	crassa	4
121.	Plexaura homomalla	2
	Plexaurella dichotoma	6
122.	Pseudoplexaura crassa	2
	Plexaurella dichotoma	4
	Eunecia crassa	4
123.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	3
	Briareum asbestum	2
125.	Gorgonia citrina	5
	Xiphigorgia anceps	2
	Plexaura flexuosa	4
	Plexaurella sp	2
	dichotoma	5
126.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	7
	Briareum asbestum	2
127.	Gorgonia flabellum	2
	citrina	4
	Xiphigorgia anceps	3
	Plexaurella dichotoma	4
130.	Barren.	
131.	Barren.	
132.	Barren.	
133.	Xiphigorgia anceps	4
	Pseudoplexaura crassa	3
	Briareum asbestum	2
134.	Gorgonia flabellum	3
	acerosa	4
	Plexaurella dichotoma	6
135.	Xiphigorgia anceps	3
	Plexaura flexuosa	2
	homomalla	1
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	4
136.	Gorgonia flabellum	3
	acerosa	2
137.	Gorgonia flabellum	2
	Xiphigorgia anceps	4
	Plexaurella dichotoma	4
	Eunecia crassa	2
138.	Plexaura flexuosa	3
	homomalla	1
	Briareum asbestum	4
139.	Gorgonia citrina	4
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	4
140.	Gorgonia flabellum	3
	Plexaurella dichotoma	5
141.	Gorgonia flabellum	2
	acerosa	3
	Pseudoplexaura crassa	3
142.	Barren.	
143.	Plexaura flexuosa	4
	Plexaurella sp	2
	dichotoma	5
	Briareum asbestum	2
144.	Xiphigorgia anceps	4
	Pseudoplexaura crassa	3
145.	Gorgonia flabellum	3
	acerosa	2
	Plexaurella dichotoma	4
146.	Gorgonia flabellum	2
	Xiphigorgia anceps	4
	Plexaura flexuosa	2
	Pseudoplexaura crassa	2
147.	Xiphigorgia anceps	3
	Plexaurella dichotoma	4
	Eunecia rousseaui	2
	crassa	4
148.	Gorgonia citrina	4
	Xiphigorgia anceps	2
	Pseudoplexaura crassa	1
	Eunecia crassa	2
149.	Gorgonia flabellum	1
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	2
150.	Plexaura flexuosa	2
	homomalla	1
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	2

Table 11.—*Details of counts along line No. 2 (see page 350 and map).*

1.	Plexaura flexuosa	4
2.	Gorgonia flabellum	2
	acerosa	1
	Plexaura flexuosa	2
	Plexaurella dichotoma	8
	Eunecia crassa	5
3.	Gorgonia flabellum	3
	Xiphigorgia anceps	2
	Gorgonia citrina	4
	Pseudoplexaura crassa	4
	Plexaurella dichotoma	5
4.	Plexaura flexuosa	5
	homomalla	1
	Pseudoplexaura crassa	3
	Eunecia rousseaui	3
	crassa	7
5.	Pseudoplexaura crassa	3
	Plexaurella dichotoma	7
	Briarem asbestum	4
6.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	3
	Plexaura flexuosa	6
	Eunecia crassa	3
7.	Gorgonia citrina	6
	Plexaurella dichotoma	5
	Briareum asbestum	3
8.	Gorgonia flabellum	4
	acerosa	2
	Pseudoplexaura crassa	2
	Eunecia rousseaui	2
	crassa	3
9.	Gorgonia acerosa	3
	Eunecia crassa	5
	Briareum asbestum	2
10.	Plexaura flexuosa	5
	Pseudoplexaura crassa	3
	Plexaurella dichotoma	5
	Eunecia rousseaui	2
11.	Gorgonia citrina	5
	Xiphigorgia anceps	2
	Plexaurella dichotoma	5
	Eunecia crassa	3
12.	Barren.	
13.	Gorgonia flabellum	3
	Eunecia crassa	7
14.	Gorgonia acerosa	2
	Plexaura flexuosa	3
	Plexaurella dichotoma	7
	Pseudoplexaura crassa	3
15.	Barren.	
16.	Pseudoplexaura crassa	3
	Plexaurella dichotoma	9
17.	Gorgonia flabellum	2
	citrina	5
	Xiphigorgia anceps	2
18.	Gorgonia flabellum	2
	Plexaura flexuosa	2
	Pseudoplexaura crassa	3
	Eunecia crassa	4
19.	Plexaura homomalla	1
	Plexaurella dichotoma	7
	Eunecia rousseaui	1
	Briareum asbestum	2
20.	Gorgonia acerosa	1
	Xiphigorgia anceps	2
	Eunecia crassa	4
21.	Gorgonia flabellum	2
	citrina	3
	Plexaura flexuosa	2
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	4
22.	Barren.	
23.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Eunecia rousseaui	2
	Briareum asbestum	2
24.	Gorgonia flabellum	2
	Xiphigorgia anceps	3
	Plexaurella dichotoma	5
	Eunecia crassa	4
25.	Plexaura flexuosa	3
	Pseudoplexaura crassa	3
	Briareum asbestum	2
26.	Gorgonia acerosa	2
	citrina	5
	Eunecia crassa	4
27.	Xiphigorgia anceps	4
	Plexaurella dichotoma	7
28.	Gorgonia flabellum	2
	acerosa	3
	Plexaura flexuosa	3
	Plexaurella dichotoma	6
29.	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
	Briareum asbestum	1
30.	Gorgonia acerosa	2

Table 12.—*Details of counts along line No. 3 (see page 350 and map).*

1.	Gorgonia flabellum	2
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	4
2.	Gorgonia citrina	3
	Xiphigorgia anceps	2
	Plexaura flexuosa	4
	Eunecia crassa	4
3.	Plexaura flexuosa	4
	Pseudoplexaura crassa	2
	Eunecia rousseaui	1
4.	Gorgonia acerosa	2
	Plexaurella dichotoma	5
	Briareum asbestum	1
5.	Gorgonia flabellum	3
	Plexaura flexuosa	4
6.	Gorgonia flabellum	1
	Xiphigorgia anceps	3
	Eunecia crassa	4
7.	Barren.	
8.	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	5
9.	Plexaurella dichotoma	5
	Pseudoplexaura crassa	3
10.	Gorgonia acerosa	3
	Eunecia rousseaui	2
	crassa	4
11.	Gorgonia flabellum	2
	acerosa	1
	Pseudoplexaura crassa	3
12.	Gorgonia flabellum	2
	citrina	5
	Xiphigorgia anceps	4
13.	Plexaura flexuosa	4
	Pseudoplexaura crassa	3
14.	Plexaura flexuosa	4
	Pseudoplexaura crassa	2
	Briareum asbestum	1
15.	Gorgonia flabellum	3
	acerosa	2
	Plexaurella dichotoma	4
16.	Gorgonia flabellum	3
	Xiphigorgia anceps	2
	Eunecia crassa	4
17.	Gorgonia acerosa	2
18.	Plexaura flexuosa	5
	Plexaurella dichotoma	3
19.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	1
	Pseudoplexaura crassa	1
20.	Gorgonia flabellum	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
	Plexaurella dichotoma	3
	Briareum asbestum	1

TABLE 13.—*Details of counts along line No. 4 (see page 350 and map).*

1.	Gorgonia flabellum	2
	acerosa	2
	Xiphigorgia anceps	3
	Plexaura flexuosa	3
	Pseudoplexaura crassa	1
2.	Gorgonia flabellum	5
	citrina	7
	Plexaura flexuosa	4
	Plexaurella dichotoma	5
3.	Plexaura flexuosa	4
	Pseudoplexaura crassa	2
	Plexaurella dichotoma	7
	sp	2
4.	Gorgonia flabellum	5
	acerosa	3
5.	Gorgonia flabellum	3
	citrina	6
	Plexaura flexuosa	4
	homomalla	1
	Plexaurella sp	2
6.	Gorgonia flabellum	2
	acerosa	3
	Xiphigorgia anceps	5
	Plexaura flexuosa	5
	Pseudoplexaura crassa	3
7.	Barren.	
8.	Plexaura flexuosa	8
	Pseudoplexaura crassa	4
	Plexaurella dichotoma	3
9.	Gorgonia flabellum	4
	citrina	6
	Xiphigorgia anceps	3
	Plexaura flexuosa	2
10.	Gorgonia acerosa	9
	Pseudoplexaura crassa	3
11.	Gorgonia flabellum	7
	Plexaura flexuosa	6
	Plexaurella sp	3
12.	Xiphigorgia anceps	4
	Plexaura flexuosa	5
	Eunecia rousseaui	3
	crassa	5
13.	Gorgonia flabellum	5
	acerosa	4
	Plexaura homomalla	1
	Pseudoplexaura crassa	3
14.	Gorgonia acerosa	8
	Plexaura flexuosa	7
	Eunecia crassa	4
15.	Gorgonia flabellum	5
	Xiphigorgia anceps	3
	Plexaura homomalla	2
	Pseudoplexaura crassa	3
16.	Plexaura flexuosa	5
	homomalla	3
	Plexaurella dichotoma	6
	sp	3
17.	Gorgonia flabellum	5
	citrina	7
	acerosa	4
	Plexaura flexuosa	5
18.	Gorgonia acerosa	7
	Pseudoplexaura crassa	4
	Plexaurella dichotoma	6
19.	Barren.	
20.	Gorgonia acerosa	7
	Xiphigorgia anceps	5
21.	Barren.	
22.	Gorgonia flabellum	7
	citrina	10
	Plexaura flexuosa	8
	Pseudoplexaura crassa	4
23.	Gorgonia acerosa	5
	Xiphigorgia anceps	3
	Plexaurella dichotoma	6
	sp	2
	Eunecia rousseaui	1
	crassa	4
24.	Gorgonia flabellum	5
	acerosa	2
	Plexaura flexuosa	4
25.	Gorgonia flabellum	1
	citrina	5
	Plexaura flexuosa	6
	Pseudoplexaura crassa	3
26.	Gorgonia acerosa	1
	Xiphigorgia anceps	2
	Plexaurella dichotoma	4
	Eunecia crassa	4
27.	Gorgonia citrina	3
	Plexaura flexuosa	2
	Plexaurella sp	2
28.	Gorgonia flabellum	4
	acerosa	6
	Pseudoplexaura crassa	3
	Eunecia crassa	4
29.	Gorgonia acerosa	1
	Xiphigorgia anceps	2
	Plexaurella dichotoma	4
30.	Gorgonia citrina	5
	Plexaura flexuosa	7
	Pseudoplexaura crassa	2
31.	Barren.	
32.	Gorgonia flabellum	8
	acerosa	10
	Plexaura homomalla	1
33.	Gorgonia acerosa	13
	Xiphigorgia anceps	5
	Plexaurella sp	4
34.	Barren.	
35.	Do.	
36.	Gorgonia flabellum	7
	citrina	11
	Plexaura flexuosa	6
	Pseudoplexaura crassa	4
37.	Barren.	
38.	Gorgonia flabellum	12
	acerosa	8
	Plexaura flexuosa	7
	Plexaurella dichotoma	3
39.	Gorgonia acerosa	7
	citrina	9
	Xiphigorgia anceps	4
	Plexaura flexuosa	5
40.	Gorgonia flabellum	5
	acerosa	4
	Plexaura flexuosa	2
	Plexaurella dichotoma	1

TABLE 14.—*Details of counts along line No. 5 (see page 351 and map).*

1.	Gorgonia acerosa	3
2.	Gorgonia acerosa	5
3.	Gorgonia acerosa	4
4.	Gorgonia acerosa	2
5.	Gorgonia acerosa	6
6.	Gorgonia acerosa	3
7.	Gorgonia acerosa	7
8.	Gorgonia acerosa	4
9.	Barren.	
10.	Gorgonia acerosa	7
11.	Gorgonia acerosa	3
12.	Gorgonia acerosa	3
13.	Gorgonia acerosa	5
14.	Gorgonia acerosa	3
15.	Gorgonia acerosa	5
16.	Gorgonia acerosa	
	Plexaura flexuosa	
	Pseudoplexaura crassa	
17.	Gorgonia flabellum	2
	acerosa	1
17.	Xiphigorgia anceps	2
	Plexaura flexuosa	3
	Pseudoplexaura crassa	2
18.	Plexaura homomalla	1
	Plexaurella dichotoma	6
	sp	1
	Eunecia crassa	3
19.	Barren.	
20.	Gorgonia acerosa	1
	citrina	3
	Pseudoplexaura crassa	1
21.	Barren.	
22.	Gorgonia flabellum	2
	Plexaura flexuosa	3
	Plexaurella dichotoma	4
23.	Gorgonia acerosa	1
	Pseudoplexaura crassa	2
	Eunecia rousseaui	1
	crassa	5
24.	Barren.	
25.	Gorgonia flabellum	2
	Xiphigorgia anceps	2
	Plexaura flexuosa	4
	Briareum asbestum	1
26.	Plexaura flexuosa	3
	homomalla	1
	Plexaurella sp	2
	Eunecia crassa	3
27.	Gorgonia acerosa	1
	Pseudoplexaura crassa	2
	Eunecia rousseaui	3
28.	Barren.	
29.	Gorgonia flabellum	2
	Xiphigrogia anceps	4
	Pseudoplexaura crassa	2
	Eunecia crassa	4
30.	Gorgonia flabellum	2
	acerosa	1
	Plexaura flexuosa	4
	Plexaurella dichotoma	3